The First International Conference on the Environmental Health and Safety of Jet Fuel

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Billions of gallons of Jet-A fuel power U.S. and international commercial airlines. An additional 4.5 billion gallons, with a few additives (anti-icing, anticorrosion, and antistatic) mixed in, becomes jet propulsion fuel (JP-8), which is used by the U.S. Air Force, other services, and North Atlantic Treaty Organization (NATO) forces to fuel their jets, power their tanks, and heat their tents and field buildings. It is similar in composition and performance to JP-5, which was developed by the Navy for shipboard service, and is also used for land-based equipment. In addition to providing the energy source to make jet planes fly, the fuel is also circulated throughout the engines and other components as a coolant.

Because of the demands for flying range, every available free space on many military aircraft is filled with fuel tanks or fuel cells (smaller tanks that are conformed to fit odd shaped areas, such as in sections of the wings). Therefore, there are many opportunities to be exposed to jet fuel and its combustion products, and there is concern about possible adverse health and environmental effects of these exposures.

In 1972, NATO member countries selected JP-8 as the single battlefield fuel for all primary air and ground vehicles and support equipment, and it was adopted by the Air Force at the same time. The changeover to JP-8 use by the Air Force has been gradual, beginning with its use in Europe and subsequently with its use in the United States. One reason for the extended changeover time is the need to modify the engines to the specifications of the changed fuel. The advantage of JP-8 over its predecessor, JP-4, is that JP-8 is less volatile and has a higher flash point (38°C vs. -18°C); therefore, it is less likely to accidentally ignite. Chemically, JP-8 is a mixture of hundreds or thousands of discrete chemicals. It is composed mostly of alkanes, primarily in the C8–C17 range (approximately 81%), with the remainder being aromatics, including substituted benzenes and naphthalenes, and relatively low levels of the highly volatile chemicals such as benzene, toluene, and xylene. The exact composition varies from batch to batch and supplier to supplier.

In addition to the advantages such as fewer volatiles, less of the carcinogen benzene, and higher boiling and flash points, there are a number of disadvantages associated with JP-8. Its higher viscosity and higher flash point means that the jet engines do not start as easily or burn as completely. Thus, more soot is produced, there is coking (buildup of soot) in engine parts, and the fuel persists as a liquid on solid surfaces and on skin. Exposure to JP-8 vapors, aerosol, and liquid occurs during engine start-up procedures and when transferring fuel, and exposure to liquids occurs during fueling and maintenance procedures. People who work at airports in nonaircraft related jobs and commercial jet passengers may also be exposed to the vapors and aerosols. Exposure and health assessment are further complicated by the fact that the fuel aerosols have different compositions and properties when they are generated during cold startup conditions (such as in the northern United States in winter) as compared to hot startup conditions (such as in the southern United States or the Arabian desert).

How much human exposure is there, and can these exposures be minimized? Are there potential adverse health effects to the personnel working on and around jets and to others (passengers and those living or working near airports) who may be incidentally exposed to jet fuel and its products? What are these effects? Are they reversible or persistent? These are some of the questions that dominated the first International Conference on the Environmental Health and Safety of Jet Fuel, held in San Antonio, Texas, 1–3 April 1998. Organized by personnel from the Air Force Industrial Hygiene Consulting Branch at Brooks Air Force Base and sponsored in part by other organizations, this conference brought together industrial hygienists, chemists, toxicologists, epidemiologists, jet fuel handlers, and fuel safety officers. The conference provided a comprehensive overview of the industrial hygiene, toxicology, and health aspects of jet fuel use and exposure.

The conference was organized into general plenary sessions and parallel subsections: Applied Research Topics and Basic Research Topics, and Environmental Aspects and two workshop sessions on developing consensus standards for worker performance and identification of basic and applied research topics, and epidemiology research programs. The keynote speaker was Gary Vest, Principal Assistant Deputy Undersecretary of Defense (Environmental Security). Vest is the principal officer within the Department of Defense for JP-8 environmental, safety, and occupational health issues.

Industrial Hygiene

During routine maintenance procedures, service personnel must enter the tanks and fuel cells. In most aircraft fuel tanks and cells, there is insufficient space and clearance to allow them to use self-contained air supplies. Additionally, these personnel wear only cotton garments to prevent the buildup of static electricity. There are currently major projects under way to measure and evaluate actual human exposure levels during aircraft fuel tank entry and to evaluate exposure to personnel working in the vicinity of the planes. The collaboration includes measuring JP-8 vapor levels (the highly volatile benzene, toluene, ethyl benzene, and xylene; the less volatile naphthas; and the total hydrocarbons) inside and around the tanks; conducting breath, and other, measurements on tank entrants; evaluating the ventilation, airline respirators, and personal protective equipment; and measurement of heat stress during tank entry. Efforts are under way to develop a national consensus standard on confined space entry into aircraft fuel tanks.

Exposure

Larger numbers of personnel are exposed on flight lines and during maintenance procedures, and a number of studies have monitored their exposures. Additional work is under way to design more effective monitoring systems. The Air Force currently has several collaborative methods development projects. One collaboration is for the development of a breath collection technique for identifying and measuring JP-8 markers in exposed personnel. This method has been

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tested on workers exposed to aerosols during cold engine starts, aircraft fuel tank entrants, flightline workers, and on a general nonexposed Air Force population. Preliminary results indicate that this is a very useful method of assessing JP-8 exposure. Other projects are in the first phase of long-term methods development. One that is currently being tested is a simplified benzene breath monitoring method, which will be economical and user friendly and will require minimal supervision. Another is on personal sampling methods development for collection of aerosol JP-8 during aircraft cold engine starts.

Monitoring

Biomonitoring has been performed using expired breath analysis for low molecular weight volatiles (e.g., benzene and hexane) and blood levels of the higher weight alkanes (e.g., nonane). Unlike benzene and hexane, the higher weight alkanes are not found in gasoline, to which many people are exposed during their normal daily routines. Additional studies are under way to identify markers that can differentiate between recent and long-term exposure to jet fuel.

Toxicology Testing

The Air Force and other components of the Department of Defense have supported extensive short-term *in vitro* and *in vivo* toxicity testing of JP-8 and JP-8+100 in rodents. ("+ 100" designates a proprietary additive package designed to increase the thermal stability and cooling efficiency of JP-8 and to reduce soot buildup.) Results of a number of biochemical, immunotoxic, and neurotoxic studies were presented. These included data which showed that short-term exposure of mice to aerosolized JP-8 produced decreases in immune organ (spleen and thymus) weights and viable immune cell numbers including T-cells and macrophages, resulting in a persistent decrease in immune system function. Aerosol administration of lung substance P protected the animals against the immunotoxicity of the jet fuel. Exposure of mice to JP-8+100 results in functional changes in proprioception, as measured by balance, and increased light sensitivity. These studies in mice will identify functional markers of exposure that can be examined in personnel who are exposed to jet fuels.

Human Health Effects

At the present, other than anecdotal reports and reports of dermatitis of the hands of some workers exposed to liquid jet fuel, there are few documented adverse human health effects of continuing exposure to JP-8 in any of its forms. There are reports of adverse effects of liver function and emotional dysfunction. A limited epidemiology study of male Air Force personnel exposed to jet fuels has recently been completed. There were no adverse effects seen in sperm counts; however, there was a small increase in sister chromatid exchanges in peripheral lymphocytes, but no consistent increase in micronuclei. Personnel also exhibited problems with vestibular proprioception, possibly due to exposure to the volatiles benzene, toluene, and xylene that are present in the fuel. An epidemiology study to assess reproductive effects in women exposed to these fuels has recently been initiated.

Future and Ongoing Studies

There was extensive discussion the last day of the conference regarding future directions for health- and industrial hygiene-related studies. In addition to collaborations with universities, there are a number of ongoing projects with the EPA National Environmental Research Laboratory for developing monitoring procedures and with the National Institute for Occupational Safety and Health for epidemiology studies.

In September 1997, the NIEHS and the U.S. Air Force (Armstrong Laboratory) signed a Memorandum of Understanding to collaborate on specific projects of public health concern. At a joint meeting in January, it was agreed that the potential health effects of exposure of military and civilian personnel to JP-8 and related fuels is of sufficient concern to warrant joint studies. Consideration is being given to conducting laboratory toxicology studies on the potential human health effects of jet fuel exposure. The information presented at the International Conference on the Environmental Health and Safety of Jet Fuel will help define the parameters of the unresolved research and health-related issues and identify data gaps that should be addressed by future research and testing.

Sponsors

Department of the Air Force
National Institute for Occupational Safety and Health
U.S. Environmental Protection Agency
American Industrial Hygiene Association

Additional Reading

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